International Journal of Clinical Oncology (2019) 24:941–949
https://doi.org/10.1007/s10147-019-01429-7

ORIGINAL ARTICLE

Removal of the entire internal iliac vessel system is a feasible surgical procedure for locally advanced ovarian carcinoma adhered firmly to the pelvic sidewall

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Received: 4 December 2018 / Accepted: 13 March 2019 / Published online: 20 March 2019

Abstract

Background Ovarian carcinomas sometimes grow in the pelvic cavity, adhering firmly to the pelvic sidewall. These cases are often considered as inoperable or result in the incomplete resection because the tumors are not mobile. We performed en bloc resection of the tumors along with the entire internal iliac vessel system to achieve complete resection.

Methods Twenty of 237 consecutive patients with FIGO stage II–IV ovarian, fallopian tubal, or primary peritoneal carcinoma who underwent cytoreductive surgery at Chiba University Hospital between January 2008 and December 2016 had locally advanced tumors adhered firmly to the pelvic sidewall. We performed isolation of the tumors from the pelvic sidewall using the following procedure: the trunk of internal iliac vessels, the obturator vessels, the inferior gluteal and internal pudendal vessels were isolated and divided. The tumor together with the entire internal iliac vessel system was isolated from the sacral nerve plexus and piriform muscle. We examined the surgical outcomes, perioperative complications, and prognosis for the patients who underwent this procedure.

Results All patients successfully underwent complete resection, resulting in no gross residual disease in the pelvic cavity. There was no mortality within 90 days postoperatively. Two patients had Grade IIIb complications, comprising wound dehiscence and vesicovaginal fistula. Recurrence occurred in nine of the patients. However, no recurrence was observed in the pelvic sidewall. The median progression-free survival was 43 months.

Conclusions Removal of the entire internal iliac vessel system is feasible for the complete resection of locally advanced ovarian carcinomas adhered firmly to the pelvic sidewall.

Keywords Ovarian cancer · Cytoreductive surgery · Complete resection · Internal iliac vessels · Sacral nerve plexus

Introduction

No gross residual disease after cytoreductive surgery is the most powerful prognostic factor for ovarian carcinoma [1–3]. Reports on surgical procedures to achieve no gross residual disease have mainly concerned upper abdominal dissemination [4–8]. However, in addition to upper abdominal dissemination, ovarian carcinomas can grow in the pelvic cavity, adhering firmly to the pelvic sidewall. The cytoreductive surgery for such tumors is challenging and often considered as inoperable or results in incomplete resection [9] because the tumor is not mobile from the pelvic sidewall.

For locally advanced cervical cancers, aggressive surgical procedures have been attempted for invasive tumors in the cardinal ligament extending to the pelvic sidewall, with the removal of the entire internal iliac vessel system. This surgical concept was introduced in 1941 by Mibayashi as "super-radical hysterectomy" [10, 11]. A similar technique for invasive cervical cancer was reported by Ungar et al., known as laterally extended parametrectomy (LEP) [12–14]. Additionally, for cases of locally advanced or recurrent cervical cancer, Höckel reported a technique for the resection of tumors involving the adjacent pelvic sidewall muscle, along with the internal iliac vessels, known as laterally extended endopelvic resection (LEER) [15–17]. All three of these surgical procedures have a common concept, which is the removal of the entire internal iliac vessel

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system to achieve complete resection and locoregional control of the locally advanced cervical cancer.

There have been few reports on ovarian carcinoma regarding the use of surgical procedures for the removal of the entire internal iliac vessel system to achieve complete resection of pelvic cavity tumors adhered firmly to the pelvic sidewall. In the present study, we applied the surgical concept of the removal of the entire internal iliac vessel system to locally advanced ovarian carcinomas adhered firmly to the pelvic sidewall and examined the feasibility, safety, and efficacy of this technique for an improved prognosis.

Materials and methods

This study is a descriptive study approved by the Institutional Review Board of Chiba University Graduate School of Medicine.

Patients' selection

From January 2008 to December 2016, 255 consecutive patients with International Federation of Gynecology and Obstetrics (FIGO) stage II–IV ovarian, fallopian tubal, or primary peritoneal carcinomas received initial treatment at Chiba University Hospital. We excluded 18 patients who showed disease progression during neoadjuvant chemotherapy. Among 237 consecutive patients who underwent cytoreductive surgery, we included patients with locally advanced tumors adhered firmly to the pelvic sidewall. We defined operable locally advanced tumor adhered firmly to the pelvic sidewall as follows:

1. Preoperative findings on computed tomography (CT) or magnetic resonance imaging: a tumor extending to the pelvic sidewall involving the internal iliac vessels, without apparent invasion to the iliac, pubic, or acetabular bone. Representative CT images are shown in Fig. 1.
2. Preoperative physical examination: a tumor which was fixed to the pelvic sidewall and not mobile from the pelvic sidewall on rectal examination, without symptoms that are suggestive of bone or nerve invasion.

The adjuvant chemotherapy regimen after primary debulking surgery and neoadjuvant chemotherapy regimen included platinum and taxane, while that after interval debulking surgery included platinum and taxane, or gemcitabine and irinotecan. Bevacizumab was used for patients with FIGO stage III/IV cancers after the Japanese public insurance approved its use in November 2013.

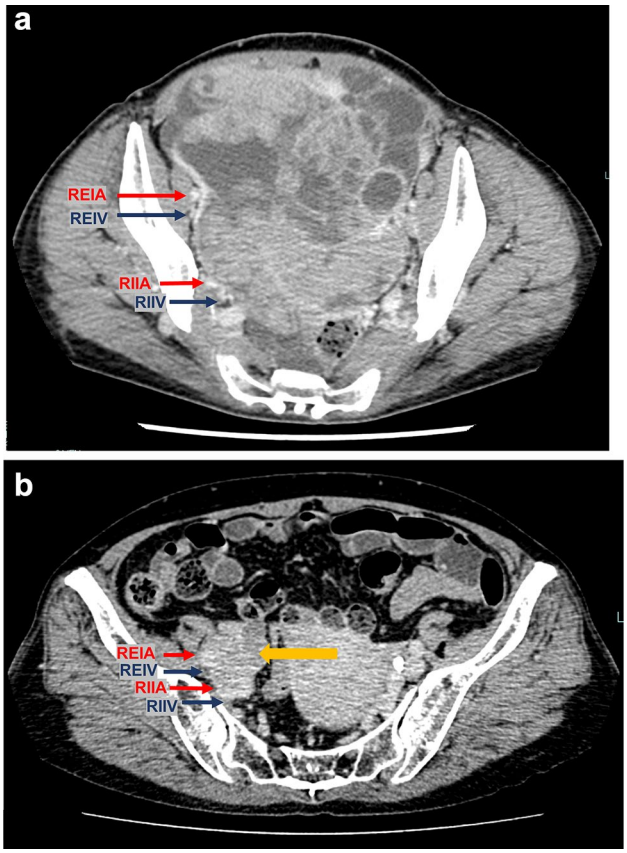

Fig. 1 Representative CT images of the patients who underwent the removal of the locally advanced tumors adhered firmly to the pelvic sidewall, along with the entire internal iliac vessel system. **a** A right ovarian carcinoma occupied the pelvic cavity and extended to the pelvic sidewall. **b** The orange arrow shows the right fallopian tubal carcinoma, which involves the right external and internal iliac artery and veins. The border of the tumor and the vessels was unclear. *REIA* right external iliac artery, *REIV* right external iliac vein, *RIIA* right internal iliac artery, *RIIV* right internal iliac vein

Surgical procedure

We performed en bloc resection of the locally advanced tumor adhered firmly to the pelvic sidewall, along with the entire internal iliac vessel system. The surgical procedures for the removal of the entire internal iliac vessel system were as follows.

The paravesical space between the obliterated umbilical artery and the external iliac vessels was developed until it was sufficiently deep to expose the internal obturator and levator ani muscles. The distal portion of the internal iliac artery was ligated and divided at the obliterated umbilical artery. The obturator vessels revealed in the paravesical space were ligated and divided at the level of the obturator foramen.

The connective tissues between the external iliac vessels and the psoas muscles were separated from the inguinal level to the common iliac level. The connective tissue was separated sufficiently deep to visualize the obturator nerve. Dorsal to the obturator nerve, the ventral branch of the sacral nerve plexus was partially visualized. The small blood vessels crossing over the ventral branch of the sacral nerve plexus were ligated and divided. Then, along the sacral nerve plexus and the piriformis muscle toward the dorsal side, the internal iliac vessels, along with the tumor, were isolated from the sacral nerve plexus and the piriformis muscle. During this procedure, the inferior gluteal, internal pudendal vessels, and additional parietal branches of the internal iliac vessels were isolated, ligated, and divided. If the tumor adhered to the piriformis muscle, the fascia of the muscle, or the muscle itself, was partially resected. As a result of these procedures, the sacral nerve plexus was exposed, and the tumor was separated from the pelvic sidewall, along with the internal iliac vessels.

Then the trunks of the internal iliac artery and vein were ligated and divided at the bifurcated portion from the common iliac vessels. While lifting the cut end of the trunk of the internal iliac artery and vein, if the dorsal branches of the internal iliac artery and vein were present, they were divided on the surface of the piriform and levator ani muscles. If the tumor adhered to the levator ani muscle, the fascia of the muscle, or the muscle itself, was partially resected. These procedures mobilized the tumor ventrally and medially from the pelvic wall, and the tumor, along with the divided internal iliac vessels, was attached to the side of the uterus or rectum.

Finally, the medial branches of the internal iliac vessels (i.e., the middle rectal vessels, superior and inferior vesical vessels, and uterine vessels) were removed. The procedure to remove the medial branches of the internal iliac vessels depended on the pelvic organ adhered to the tumor. For example, if the tumor did not adhere to the rectum or bladder, the tumor and uterus, along with the uterine vessels, were resected together. Then the superior and inferior vesical vessels were ligated and divided at the vesico-uterine ligament. In addition, the middle rectal vessels were ligated and divided when the sacro-uterine ligament or recto-vaginal ligament was resected. If the tumor adhered to the rectum, the tumor was resected with the uterus and the rectum dividing the uterine vessels and middle rectal vessels. If the tumor adhered to the bladder, partial resection of the bladder with the tumor and the uterus, along with the superior and inferior vesical vessels, was performed.

Ultimately, the locally advanced tumor was completely resected from the pelvic sidewall, along with the internal iliac vessels, and the uterus, rectum, and/or bladder. Figure 2 shows the schema of the surgical procedure. An intraoperative view of the pelvic sidewall after tumor resection is shown in Fig. 3.

Surgical outcomes

The complete cytoreduction rate, histological findings, recurrent rate, site of recurrence, survival, the volume of intraoperative blood loss, and perioperative complications were evaluated. Complications related to the surgical procedure were classified and graded according to the Clavien–Dindo classification system [18].

Statistical analysis

Survival analyses were performed using the Kaplan–Meier method and log-rank test. IBM SPSS Statistics, version 22 (IBM Corporation, Tokyo, Japan) was used for statistical analysis. A P value of < 0.05 was considered statistically significant.

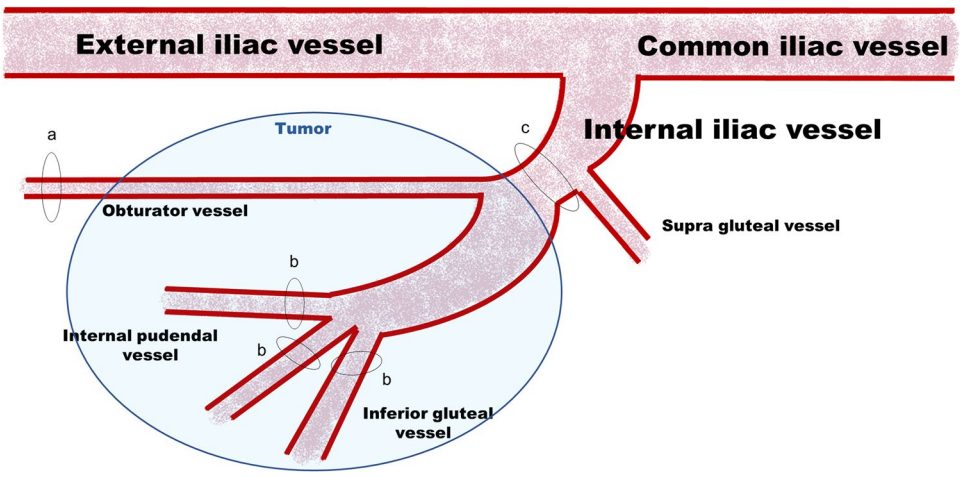

Fig. 2 The schema of surgical procedure for en bloc resection of the tumor along with the entire internal iliac vessel system. **a** Ligation and division of obturator vessels at the site of obturator foramen. **b** Ligation and division of inferior gluteal vessels and internal pudendal vessels. **c** Ligation and division of trunk of internal iliac vessels at the bifurcation just below the supra gluteal vessels

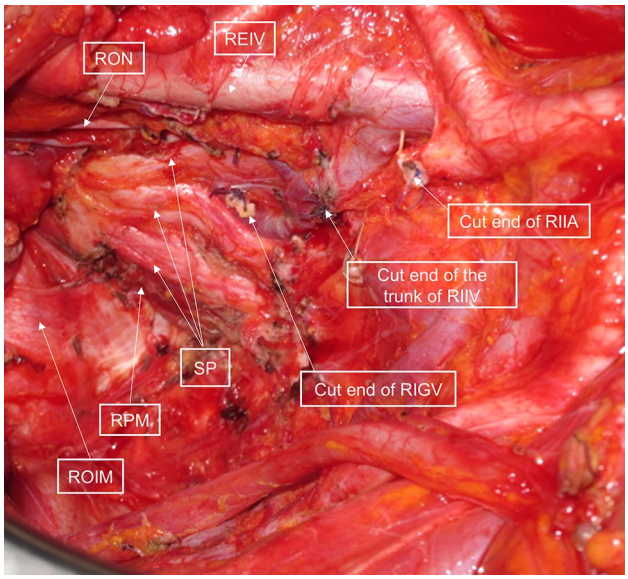

Fig. 3 The right side of the pelvic sidewall after en bloc tumor resection, with the removal of the entire internal iliac vessel system. *REIV* right external iliac vein, *RIIV* right internal iliac vein, *RIIA* right internal iliac artery, *RIGV* right inferior gluteal vein, *RON* right obturator nerve, *SP* sacral nerve plexus, *ROIM* right obturator internus muscle, *RPM* right piriformis muscle

Results

Patient characteristics

Twenty (8%) of the 237 consecutive patients with FIGO stage II–IV ovarian, fallopian tubal, or primary peritoneal carcinomas had locally advanced tumors adhered firmly to the pelvic sidewall. These 20 patients underwent the removal of the entire internal iliac vessel system. Patient characteristics are shown in Table 1.

Surgical outcomes

All 20 patients successfully underwent complete cytoreduction of the locally advanced tumor, resulting in no residual disease in the pelvic cavity.

Additional surgical procedures, such as rectosigmoid colon resection (15 cases), nephroureterectomy (4 cases), common/external iliac vessel resection with graft reconstruction (2 cases), and partial cystectomy (1 case), were necessary to accomplish en bloc resection of the pelvic tumors.

For complete cytoreduction of the upper abdominal cavity, additional surgical procedures, such as diaphragm resection (9 cases), colon resection (5 cases), and splenectomy with distal pancreatectomy (3 cases), were performed. All 20 patients underwent pelvic and para-aortic lymphadenectomy (Table 1).

Histological findings of the resected internal iliac vessels, pelvic sidewall muscles, or pelvic floor muscles.

Table 1 Patient characteristics

Parameters	$n=20$
Median age (range)	64.5 (38–75) years
Primary site	
Ovary	16
Fallopian tube	3
Peritoneum	1
FIGO stage[a]	
IIA	1
IIB	2
IIIA	4
IIIB	1
IIIC	5
IVA	1
IVB	6
TNM stage[b]	
T	
1c	1
2b	7
3b	2
3c	10
N	
0	6
1	14
M	
0	13
1	7
Peritoneal cancer index[c]	
≤10	14
>10	4
Histological type	
High-grade serous	13
Endometrioid	5
Low-grade serous	1
Carcinosarcoma	1
The timing of debulking surgery	
Primary	16
Interval	4
Surgical procedure performed other than standard gynecological procedure	
Pelvic and para-aoritic lymph node dissection	20
Rectosigmoid resection	15
Ureter resection and/or nephrectomy	4
Common/external iliac artery and vein resection with graft reconstruction	2
Partial cystectomy	1
Diaphragm resection	9
Colon resection	5
Splenectomy with distal pancreatectomy	3

Table 1 (continued)

Parameters	$n = 20$
Macroscopic residual tumor	
No	18
0.1–1 cm	2[d]
> 1 cm	0
Chemotherapy	
Adjuvant chemotherapy, platinum and taxane	17[e]
Adjuvant chemotherapy, non-platinum and taxane	2
Neoadjuvant chemotherapy, platinum and taxane	4[f]
Maintenance therapy, bevacizumab	4[g]

[a]FIGO 2014 classification

[b]UICC 8th edition

[c]The peritoneal cancer index of the two patients was not evaluated because the explore laparotomy was not performed before neoadjuvant chemotherapy

[d]One was left at mesentery of small intestine, the other was left at central tendon of left diaphragm

[e]The median cycles were 6. One patient refused adjuvant chemotherapy

[f]The median cycles were 6

[g]The median cycles were 21

The median size of the resected pelvic sidewall tumor after formalin fixation was 8 cm (range 2.7–18 cm).

Of the 20 resected tumors, only one tumor was found to have infiltrated the adventitia of the internal iliac artery and vein upon histological analysis (Fig. 4). Additionally, only one tumor was found to have infiltrated the levator ani muscles upon histological analysis.

Recurrent rate, site of recurrence, and survival

The median follow-up time was 50 months (range 14–115 months). Recurrence occurred in 9 of the 20 patients. The recurrent sites included the liver (3 cases), para-aortic lymph nodes (2 cases), mediastinal lymph nodes (1 case), rectum (1 case), cecum (1 case), ileal mesenteric lymph nodes (1 case), bladder (1 case), and lung (1 case). No recurrence was observed in the pelvic sidewall.

The median progression-free survival was 43 months. The median overall survival was not reached. The 5-year progression-free survival and overall survival were 49% and 71%, respectively (Fig. 5).

Intraoperative blood loss

The median intraoperative blood loss was 4190 mL (IQR 2735–8870 mL), which included whole blood loss

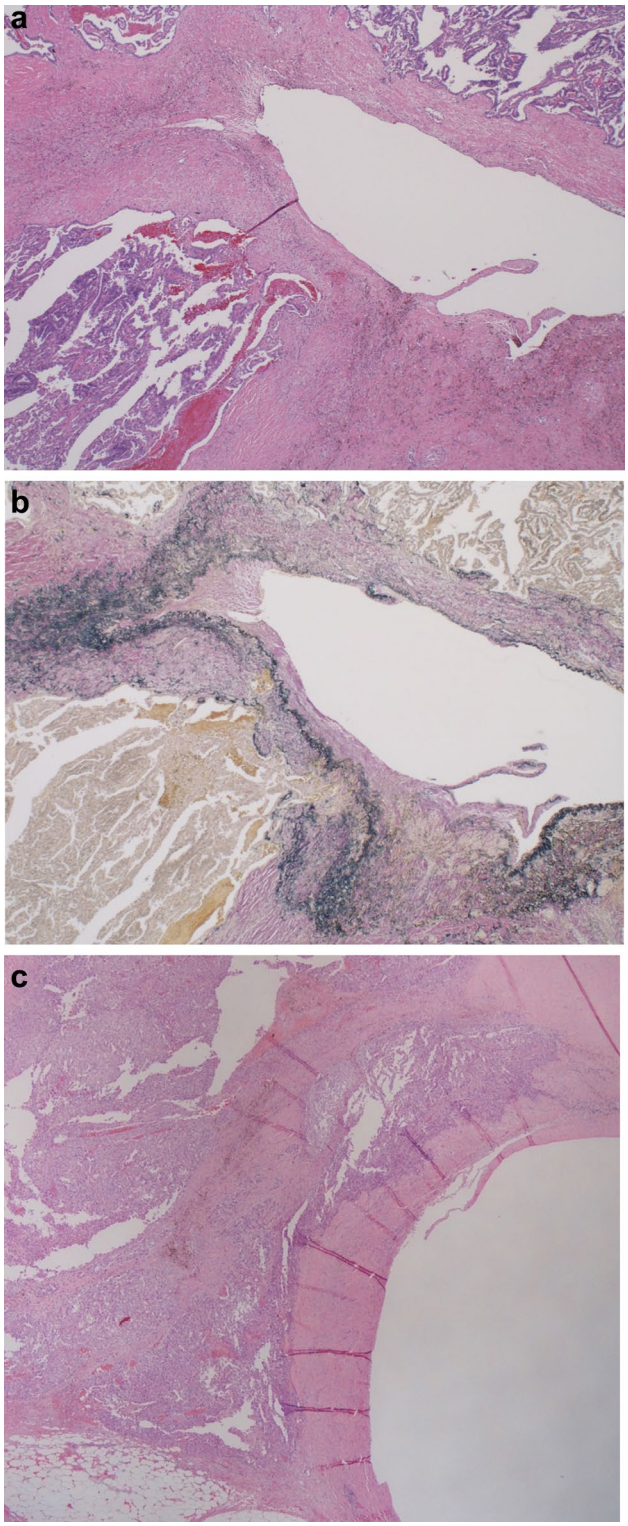

Fig. 4 Microscopic view of the carcinoma. **a, b** The tumor cells infiltrated the adventitia of the internal iliac vein (**a** hematoxylin–eosin stain, ×40, **b** Elastica van Gieson stain, ×40). **c** The tumor cells with fibrosis were adjacent to the adventitia of the internal iliac artery and partially infiltrated the adventitia of the internal iliac artery (hematoxylin–eosin stain, ×40)

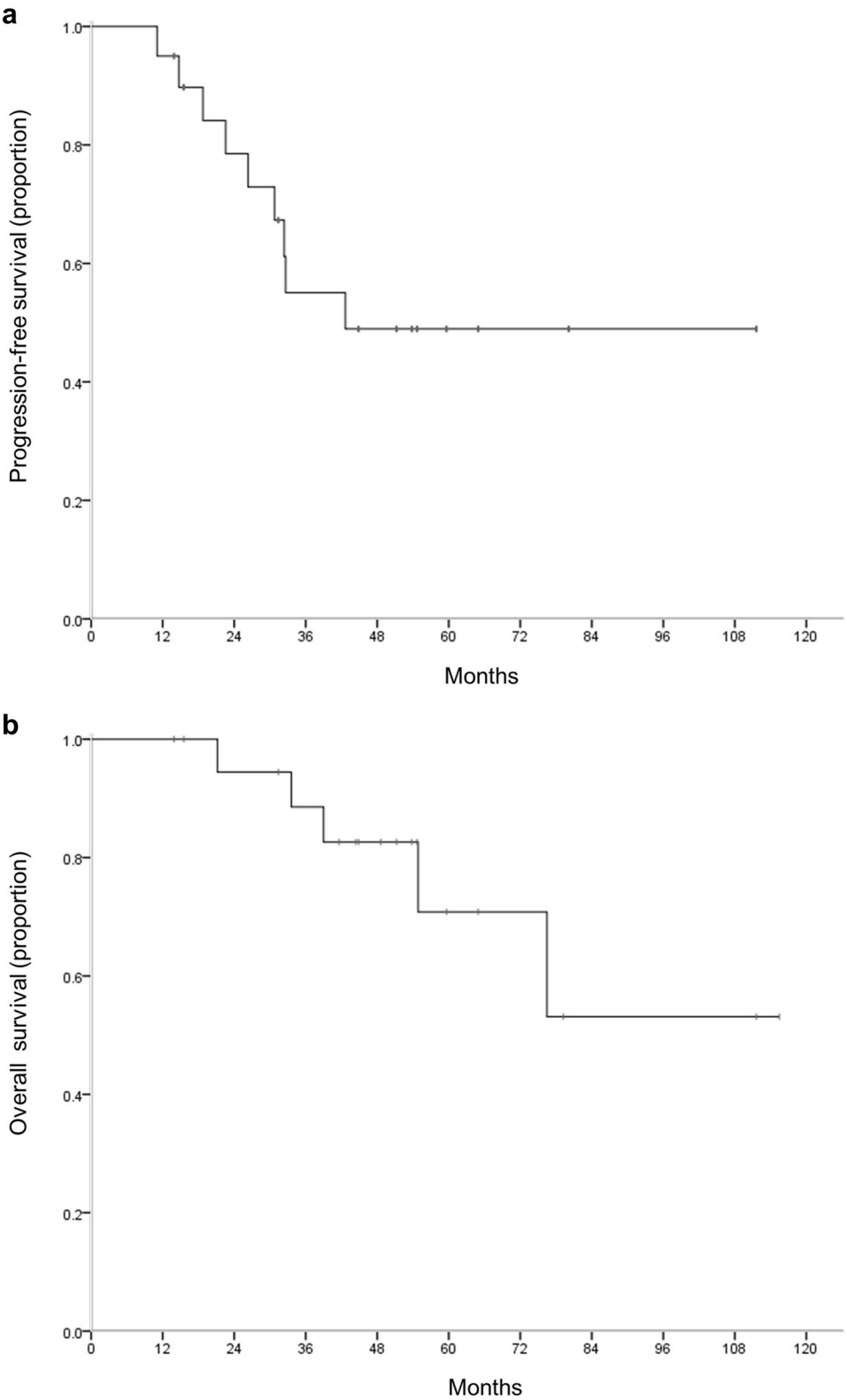

Fig. 5 Kaplan–Meier graphs. **a** Progression-free survival. **b** Overall survival

throughout the operation other than pelvic procedures such as upper abdominal surgery and pelvic–para-aortic lymphadenectomy. During the period from January 2008 to March 2012, we sometimes experienced severe bleeding from the internal iliac vein due to the splitting of the vein itself or ligature slippage from congested and swelled peripheral branches of the internal iliac vein. We considered that initially performing ligation and division of the trunk of the

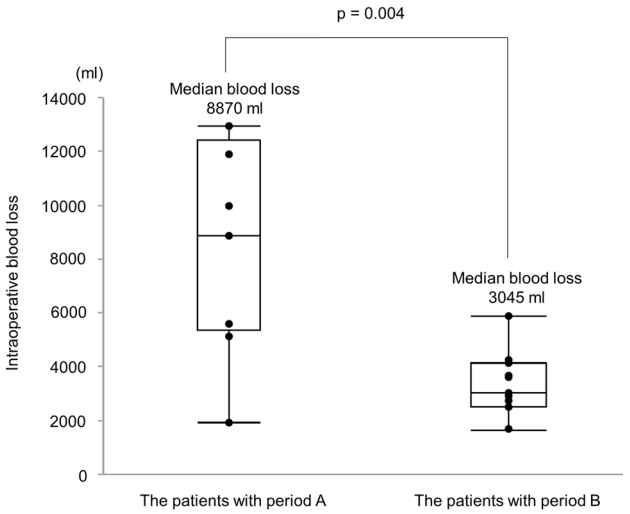

Fig. 6 Intraoperative blood loss according to the order of the ligation of the internal iliac veins. Period A: from January 2008 to March 2012, the inferior gluteal and internal pudendal veins were ligated and divided after the ligation and division of the internal iliac vein at the bifurcation. Period B: from April 2012 to December 2016, the inferior gluteal and internal pudendal veins were ligated and divided prior to the ligation and division of the internal iliac vein at the bifurcation

internal iliac vein at the bifurcation site (Fig. 2a → c → b, or c → a → b) could have induced congestion and swelling of the peripheral branches of the internal iliac vein. Therefore, since April 2012, we have ligated and divided the inferior gluteal and internal pudendal veins prior to the ligation of the trunk of the internal iliac vein at the bifurcation (Fig. 2a → b → c). Consequently, we compared the blood loss during the period from January 2008 to March 2012 to that observed during the period from April 2012 and December 2016. The median intraoperative blood loss in the latter period (3045 mL) was significantly less than that in the former period (8870 mL) ($P = 0.004$) (Fig. 6). The median amounts of transfusion in the latter period were also significantly less than that in the former period (6 units and 12 units of red blood cell, 8 units and 16 units of fresh frozen plasma, respectively).

Perioperative complications

Death did not occur in any patient during surgery or within 90 days postoperatively. The postoperative bleeding did not also occur. Two patients stayed in the intensive care unit for 1 day after the operation and one patient for 3 days.

Two patients had Grade IIIb complications, comprising wound dehiscence and vesicovaginal fistula, requiring further surgery. Two patients had Grade IIIa complications, comprising ureteral leakage, treated with percutaneous nephrostomy or the placement of a double-J ureteral catheter under cystoscopic guidance. Grade I/II complications associated with this procedure included sciatic nerve paralysis (7 cases), wound dehiscence (2 cases), chylous leakage (2 cases), urinary voiding dysfunction requiring self-catheterization (2 cases), rectovaginal fistula (1 case), lymphedema (1 case), and ileus (1 case) (Table 2).

Table 2 Postoperative complications

	Number of patients		
	Grade I/II	Grade IIIa	Grade IIIb
Early (< 30 days after operation)			
Sciatic nerve palsy	7	0	0
Wound dehiscence	2	0	1
Ureteral leakage	0	2	0
Urinary dysfunction	2	0	0
Chylous leakage	2	0	0
Ileus	1	0	0
Late (≥ 30 days after operation)			
Vesicorectal fistula	0	0	1
Rectvaginal fistula	1[a]	0	0
Lymphedema	1	0	0

[a]Diverting ileostomy was already performed during primary debulking surgery

Discussion

In the present study, we employed en bloc tumor resection, along with the resection of the entire internal iliac vessel system, as cytoreductive surgery for ovarian carcinomas adhered firmly to the pelvic sidewall. The study results showed that this surgical procedure is feasible and can achieve no gross residual disease in the pelvic cavity.

The surgical treatment of locally advanced ovarian carcinomas adhered firmly to the pelvic sidewall is challenging, as the separation of the tumor tissues from the external and internal iliac vessels is often very difficult. There is a similar surgical difficulty in the separation of invasive tumors surrounding the internal iliac vein in cases of cervical cancer with parametrial invasion. However, in 1941, Mibayashi introduced a new surgical technique concept: en bloc removal of the invasive tumors surrounding these vessels by the extirpation of the entire internal iliac vessel system [10, 11].

The present study showed no tumor invasion in the sacral nerve plexus. Thus, the medial side of the sacral nerve plexus is one of the appropriate surgical planes for separation from the pelvic sidewall tumor. Höckel reported that in cases of cervical cancer, margin-free resection of the pelvic sidewall tumor could be achieved by the resection of the internal iliac vessels and pelvic sidewall muscles, along with the exposure

of the sacral nerve plexus [16]. Histologically, there was no infiltration into the internal iliac vessels or the pelvic sidewall muscles in Höckel's study. In contrast, two cases in the present study showed histological invasion into the internal iliac vessels or the fascia of the pelvic sidewall muscles. This result implies that resection of the internal iliac vessels and the fascia, with a thin muscle layer of the suspected invasive portion of the pelvic sidewall muscle, may be necessary for the local control of tumor cells. In addition, histological examination revealed that in most patients, the tumor cells were adjacent to the internal iliac vessels. This finding implies that exfoliation of the tumor from the internal iliac vessels would have been associated with a high risk of vascular injury and the retaining of residual tumor cells even if the surgery had been performed after neoadjuvant chemotherapy, which may induce fibrosis [19–22].

Removal of the entire internal iliac vessel system has a risk of massive bleeding from the base of the pelvic cavity. Injury to the internal iliac vein is reported as a major cause of extensive blood loss during abdominal or pelvic operations [23]. During the surgical extirpation of the entire internal iliac vessel system, our earliest surgeries started ligation and division from the main central trunk to the peripheral branches of the internal iliac vessels. Gradually, we noticed that congestion and swelling of the peripheral internal iliac veins could induce ligature slippage or splitting of the peripheral internal iliac vein. Therefore, we changed this surgical step, ligating from the peripheral to the central (rather than from the central to the peripheral). This change reduced the intraoperative blood loss significantly.

During surgery for ovarian carcinomas, there is insufficient space for the ligation and division of the internal iliac vein [24], as ovarian carcinomas usually occupy a large space in the pelvic cavity. Therefore, for locally advanced ovarian carcinomas, it is recommended to ligate and divide the internal iliac vein from the peripheral branches prior to ligation and division from the central trunk. To accomplish the safe removal of a pelvic sidewall tumor, along with the entire internal iliac vessel system, it is necessary to develop a space between the internal iliac vessels and the sacral nerve plexus. The developed space allows the ligation and division of the parietal branches of the internal iliac veins. As a result, pelvic sidewall tumors, along with the internal iliac vessels, can be lifted from the pelvic sidewall and shifted toward the uterus and rectum.

The removal of the entire internal iliac vessel system appears to contribute to a good prognosis in patients with a locally advanced ovarian carcinoma adhered firmly to the pelvic sidewall. In the present study, none of the patients experienced recurrence at the pelvic sidewall. In addition, the median progression-free survival was 43 months, despite the presence of FIGO stage III or IV disease in 17 of the 20 patients. Although peritoneal cancer index scores of ≤ 10 in most patients in this study may be responsible for the good prognosis, the progression-free and overall survival rates observed were higher than those in patients with low peritoneal cancer index scores in other studies [25, 26]. We considered that surgical effects contributed to the prognosis because the chemotherapy regimens used in this study were not different from the standard regimens used in many other institutions.

Complications requiring intervention under general anesthesia (Grade IIIb) occurred in 2 patients (10%). The characteristic complication in the present study was sciatic nerve paralysis. Exposing the sacral nerve plexus damages its motor and sensory functions. The symptoms of sciatic nerve paralysis included difficulty in walking and leg pain. However, the movement of the lower extremity improved within 1–6 months of rehabilitation and the leg pain was controlled by analgesics. Thus, the symptoms were deemed acceptable.

This study had some limitations that need to be acknowledged. This study did not evaluate the effect of chemotherapy. We did not evaluate whether primary debulking surgery would have been unnecessary in the 16 patients who underwent this procedure if they had received neoadjuvant chemotherapy. Primary debulking surgery was chosen for these 16 cases for two reasons. First, neoadjuvant chemotherapy does not always reduce adhesion between the tumor and the vessels. It sometimes produces difficulties in surgery due to chemotherapy-induced fibrosis [19, 24–26]. Microscopic examination of tumors in patients who underwent primary debulking surgery revealed that the tumor cells were adjacent to the adventitia of the vessels (Fig. 4). If the tumor cells adjacent to the adventitia of the vessels develop fibrosis after neoadjuvant chemotherapy, exfoliating these cells from the vessels is difficult. Second, the standard treatment for advanced ovarian cancer involves primary cytoreductive surgery followed by platinum and taxane chemotherapy. According to guidelines provided by the American Society of Clinical Oncology [27] and the Japan Society of Gynecologic Oncology [28], patients with high perioperative risk profiles or low likelihoods of achieving cytoreduction are not suitable for primary cytoreductive surgery. In most studies, patients with IIIc or IV stage disease received neoadjuvant chemotherapy. By contrast, 7 of the 16 patients who underwent primary debulking surgery in this study had stage II–IIIb disease and, therefore, had high likelihoods of achieving cytoreduction. If we had administered neoadjuvant chemotherapy in these 16 cases, some patients would have missed the opportunity to undergo interval debulking surgery because the histology of another 7 of the 16 patients showed non-high-grade serous carcinoma.

Another limitation was that the number of patients who received this procedure was small. During 9 years of the study period, only 20 of the 237 patients with FIGO stage II–IV ovarian, fallopian tubal, or primary peritoneal

carcinoma had a tumor extension that was adhered firmly to the pelvic sidewall. Thus, ovarian, fallopian tubal, and primary peritoneal carcinoma rarely show pelvic extension adhered firmly to the pelvic sidewall. Despite this limitation, this technique would be helpful to achieve complete resection, which is the most powerful prognostic factor, even in cases considered inoperable so far.

In conclusion, the removal of the entire internal iliac vessel system for locally advanced ovarian carcinomas adhered firmly to the pelvic sidewall is a feasible, safe, and efficacious method to improve the prognosis. This procedure shall be helpful for gynecologic surgeons who would like to achieve no gross disease after cytoreductive pelvic surgery for locally advanced ovarian carcinomas. Therefore, large studies are required to confirm the efficacy of this technique.

Acknowledgements We would like to acknowledge Dr. Shingo Fujii, Emeritus Professor of Kyoto University, for reviewing and editing the manuscript.

Compliance with ethical standards

Conflict of interest The authors declare no conflicts of interest.

References

1. Griffiths CT (1975) Surgical resection of tumor bulk in the primary treatment of ovarian carcinoma. Natl Cancer Inst Monogr 42:101–104
2. Eisenkop SM, Friedman RL, Wang HJ (1998) Complete cytoreductive surgery is feasible and maximizes survival in patients with advanced epithelial ovarian cancer: a prospective study. Gynecol Oncol 69(2):103–108
3. Chi DS, Eisenhauer EL, Lang J et al (2006) What is the optimal goal of primary cytoreductive surgery for bulky stage IIIC epithelial ovarian carcinoma (EOC)? Gynecol Oncol 103(2):559–564
4. Chi DS, Eisenhauer EL, Zivanovic O et al (2009) Improved progression-free and overall survival in advanced ovarian cancer as a result of a change in surgical paradigm. Gynecol Oncol 114(1):26–31
5. Kehoe SM, Eisenhauer EL, Chi DS (2008) Upper abdominal surgical procedures: liver mobilization and diaphragm peritonectomy/resection, splenectomy, and distal pancreatectomy. Gynecol Oncol 111(2 Suppl):S51–S55
6. Aletti GD, Dowdy SC, Gostout BS et al (2006) Aggressive surgical effort and improved survival in advanced-stage ovarian cancer. Obstet Gynecol 107(1):77–85
7. Cliby W, Dowdy S, Feitoza SS et al (2004) Diaphragm resection for ovarian cancer: technique and short-term complications. Gynecol Oncol 94(3):655–660
8. McCann CK, Growdon WB, Munro EG et al (2011) Prognostic significance of splenectomy as part of initial cytoreductive surgery in ovarian cancer. Ann Surg Oncol 18(10):2912–2918
9. Pawlik TM, Skibber JM, Rodriguez-Bigas MA (2006) Pelvic exenteration for advanced pelvic malignancies. Ann Surg Oncol 13(5):612–623
10. Mibayashi R (1941) Hukushiki-Choukouhannsei-sikyuukeigantekisyutsuzyutsu (in Japanese). (Abdominal super-radical hysterectomy). J Jpn Obstet Gynecol Soc, p 480
11. Mibayashi R (1970) Mibayashi-Zyutsushiki (in Japanese). (Mibayashi's super-radical hysterectomy). Gendai-sankahuzinkataikei 8E Tokyo: Nakayama-Shoten Co., pp 269–279
12. Ungar L, Palfalvi L (2003) Surgical treatment of lymph node metastases in stage IB cervical cancer: the laterally extended parametrectomy (LEP) procedure. Int J Gynecol Cancer 13(5):647–651
13. Palfalvi L, Ungar L (2003) Laterally extended parametrectomy (LEP), the technique for radical pelvic side wall dissection: feasibility, technique and results. Int J Gynecol Cancer 13(6):914–917
14. Ungar L, Palfalvi L, Tarnai L et al (2011) Surgical treatment of lymph node metastases in stage IB cervical cancer. The laterally extended parametrectomy (LEP) procedure: experience with a 5 year follow-up. Gynecol Oncol 123(2):337–341
15. Höckel M (1999) Laterally extended endopelvic resection: surgical treatment of infrailiac pelvic wall recurrences of gynecologic malignancies. Am J Obstet Gynecol 180(2 Pt 1):306–312
16. Höckel M (2003) Laterally extended endopelvic resection. Novel surgical treatment of locally recurrent cervical carcinoma involving the pelvic side wall. Gynecol Oncol 91(2):369–377
17. Höckel M (2008) Laterally extended endopelvic resection (LEER)--principles and practice. Gynecol Oncol 111(2 Suppl):S13–S17
18. Dindo D, Demartines N, Clavien PA (2004) Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 240(2):205–213
19. Vergote I, Amant F, Kristensen G et al (2011) Primary surgery or neoadjuvant chemotherapy followed by interval debulking surgery in advanced ovarian cancer. Eur J Cancer 47(Suppl 3):S88–S92
20. Hynninen J, Lavonius M, Oksa S et al (2013) Is perioperative visual estimation of intra-abdominal tumor spread reliable in ovarian cancer surgery after neoadjuvant chemotherapy? Gynecol Oncol 128(2):229–232
21. Le T, Williams K, Senterman M et al (2007) Histopathologic assessment of chemotherapy effects in epithelial ovarian cancer patients treated with neoadjuvant chemotherapy and delayed primary surgical debulking. Gynecol Oncol 106(1):160–163
22. Vergote I, du Bois A, Amant F et al (2013) Neoadjuvant chemotherapy in advanced ovarian cancer: on what do we agree and disagree? Gynecol Oncol 128(1):6–11
23. Oderich GS, Panneton JM, Hofer J et al (2004) Iatrogenic operative injuries of abdominal and pelvic veins: a potentially lethal complication. J Vasc Surg 39(5):931–936
24. Nishikimi K, Tate S, Matsuoka A et al (2017) Complete resection of locally advanced ovarian carcinoma fixed to the pelvic sidewall and involving external and internal iliac vessels. Gynecol Oncol 146(2):436–437
25. Tentes AA, Tripsiannis G, Markakidis SK et al (2003) Peritoneal cancer index: a prognostic indicator of survival in advanced ovarian cancer. Eur J Surg Oncol 29(1):69–73
26. Gasimli K, Braicu EI, Richter R et al (2015) Prognostic and predictive value of the peritoneal cancer index in primary advanced epithelial ovarian cancer patients after complete cytoreductive surgery: study of tumor bank ovarian cancer. Ann Surg Oncol 22(8):2729–2737
27. Wright A, Bohlke K, Armstrong DK et al (2016) Neoadjuvant chemotherapy for newly diagnosed, advanced ovarian cancer: society of gynecologic oncology and American society of clinical oncology clinical practice guideline. Gynecol Oncol 143(1):3–15
28. Komiyama S, Katabuchi H, Mikami M et al (2016) Japan Society of Gynecologic Oncology guidelines 2015 for the treatment of ovarian cancer including primary peritoneal cancer and fallopian tube cancer. Int J Clin Oncol 21(3):435–446